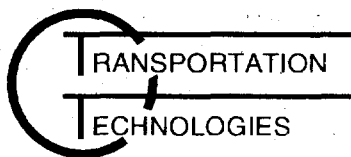


HYBRID ELECTRIC VEHICLES

**What you
should know**

U.S. Department of Energy



What is a hybrid electric vehicle?

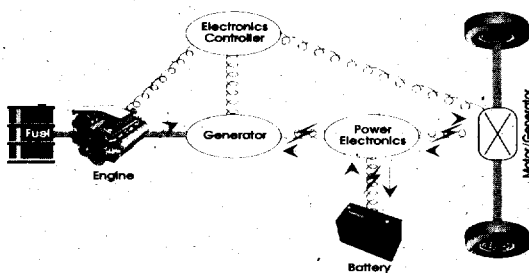
Hybrid electric vehicles (HEV) combine the best of both worlds when it comes to transportation technology. HEVs combine the engine and fuel tank of a conventional vehicle with the battery and electric motor of an electric vehicle in a single drivetrain. This combination yields the rapid refueling and long driving range of conventional vehicles with the energy savings and environmental benefits of electric vehicles. The drivetrains can be used separately or simultaneously, as driving conditions dictate.

How does an HEV work?

While there are many HEV configurations, they can be grouped into one of two categories:

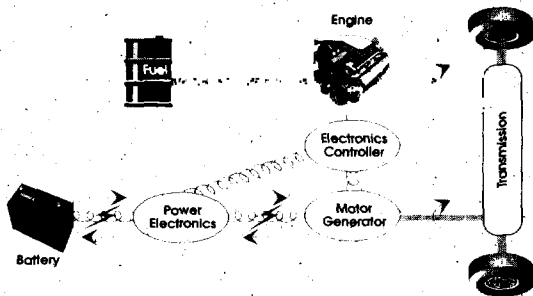
- *Series Hybrid*
- *Parallel Hybrid*

Representative Series Hybrid



In a series HEV, the engine, which operates at its most efficient speed, drives an electric generator. This generator powers an electric motor which drives the wheels and can charge the batteries. In this configuration engine speed and vehicle speed are independent because the "road load" (i.e., aerodynamic drag, tire rolling resistance, inertia) is separated from the engine.

Representative Parallel Hybrid



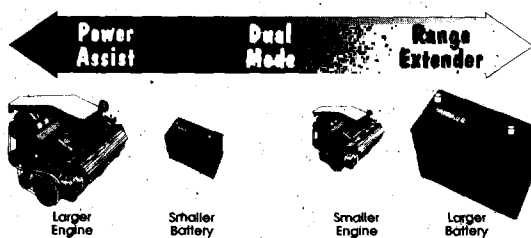
In a parallel HEV there are two power paths. Both the internal combustion and electrical propulsion systems are directly connected to the wheels of the car. Either the internal combustion or electrical propulsion system can be used separately to power the vehicle, or their output can be combined when additional power is needed.

In either type of HEV, excess electrical energy is stored in the batteries during periods of low power demand such as coasting and idling. During periods of high power demand such as acceleration and hill-climbing, energy from the batteries can be used to supplement the energy from the generator.

Are all HEVs the same?

No; hybrids can be further classified according to the relative capacities of the battery and engine as follows:

Hybrid Vehicle Types



The Power Assist configuration can be a series or parallel hybrid with a larger engine in comparison with the battery. This HEV would be driven primarily by the engine, with the battery assisting during hill climbing or during hard acceleration.

The Range Extender configuration is essentially an electric vehicle with an on-board charging system. This capability provides additional driving range when the batteries are depleted.

Dual Mode HEVs have the ability to run on either completely electric, fuel only, or some combination. In any HEV configuration, an electronic controller will automatically select the best combination of battery and engine power that results in the least fuel consumption and emissions.

What are some of the differences between HEVs and conventional vehicles?

The electric drive and energy storage systems on HEVs enable these vehicles to recapture some of the energy that would normally be lost when braking in a conventional vehicle. This is important because the recovered energy can be stored for later use.

An HEV's engine does not need to supply the vehicle's peak power requirements, and can therefore be significantly smaller than the engine in an equivalent-performance conventional vehicle. The batteries supplement the generator output to meet peak power demands (i.e., acceleration). This function yields some of the benefits of HEVs.

What are the benefits of HEVs?

HEVs take advantage of the many benefits of electric propulsion while maintaining the range and flexibility of a conventional vehicle:

- ***Improved fuel economy***

It is estimated that an HEV's fuel economy can double that of a conventional vehicle. HEV progress has been made in improving fuel economy while maintaining low emissions.

- *Lower emissions*

When operated on electric power only, HEVs have zero tailpipe emissions. When using the engine, HEVs will emit fewer pollutants than comparable conventional vehicles, corresponding roughly to the increase in fuel economy. HEVs have the capability of using petroleum or alternative fuels (non-petroleum-fueled). Alternative fuels would help reduce vehicle emissions even lower than those of petroleum-fueled HEVs.

How feasible is the future widespread production of HEVs in the U.S.?

Increasing awareness of environmental issues has created a positive setting for the development of hybrid electric vehicles. Current automotive and electric power systems technology is adequate for the design and production of HEVs. However, there are several other issues that need to be addressed before widespread production is considered, including:

- *Competitive costs*
- *Quiet/smooth operation*
- *Consumer acceptance.*

What is the future role of hybrid electric vehicles?

The future role of HEVs is still being defined. Both the Federal Government and private industry are working on the development of HEVs as a practical way of providing clean and efficient transportation for the future. The flexibility of hybrid electric vehicles will allow their use in applications ranging from personal transportation to commercial use.

Where can I get more information on HEVs?

For additional information on HEVs, please write to:

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